Varghese et al. Journal of Cardiovascular Magnetic Resonance 2016, 18(Suppl 1):W29
http://www.jcmr-online.com/content/18/S1/W29

Journal of Cardiovascular Magnetic Resonance

WORKSHOP PRESENTATION Open Access

Venous oxygen saturation estimation from multiple T2 maps with varying inter-echo spacing

Juliet Varghese[1,2*], Rizwan Ahmad[3], Ning Jin[4], Lee C Potter[3], Orlando P Simonetti[5,6]

From 19th Annual SCMR Scientific Sessions
Los Angeles, CA, USA. 27-30 January 2016

Background

Dependence of blood T2 on O2 saturation has led to non-invasive MRI-based techniques for determining venous O2 saturation (SvO_2) [1-3]. However, applying a general calibration factor derived from in vitro experiments can lead to inaccurate and largely varying SvO_2 estimates in the target population. We aim to show that based on the Luz-Meiboom relation $1/T2 = 1/T2o + Hct(1-Hct)\ \tau_{ex}[(1-\%SO_2/100)\alpha\omega_0]^2(1-2*\tau_{ex}/\tau_{180}\ \tanh(\tau_{180}/2*\tau_{ex}))$[4], individual SvO_2 can be determined from multiple T2 maps, each acquired at a specific inter-echo spacing (τ_{180}).

Methods

Three T2 prepared SSFP quantitative T2 maps (τ_{180}=10, 12 and 15 ms, TR >3000 ms, FA = 40^0, 2.8 × 2.8 × 10 mm^3, 2NEX, free breathing) were acquired in seven volunteers (age: 32.6 ± 12.2 yrs) on a 3T MRI system (Tim Trio, Siemens Healthcare). T2 preparation involved an MLEV refocusing pulse train with 2, 4, 8 and 12 composite pulses. Venous and arterial blood T2 were measured in each map in an ROI in the ventricles. For each subject, the multiple τ_{180} measurements were processed jointly to estimate SvO_2 along with other nuisance parameters (T2o and τ_{ex}) via constrained non-linear least squares fitting in Matlab (The Mathworks Inc, Natick, MA, USA). The values of hematocrit (Hct), arterial O2 saturation (SaO_2), and α were fixed at 41%, 97%, and 0.4 ppm respectively.

Results

Figure 1 shows T2 maps acquired in a volunteer. Table 1 shows mean ± SD of venous and arterial T2 and

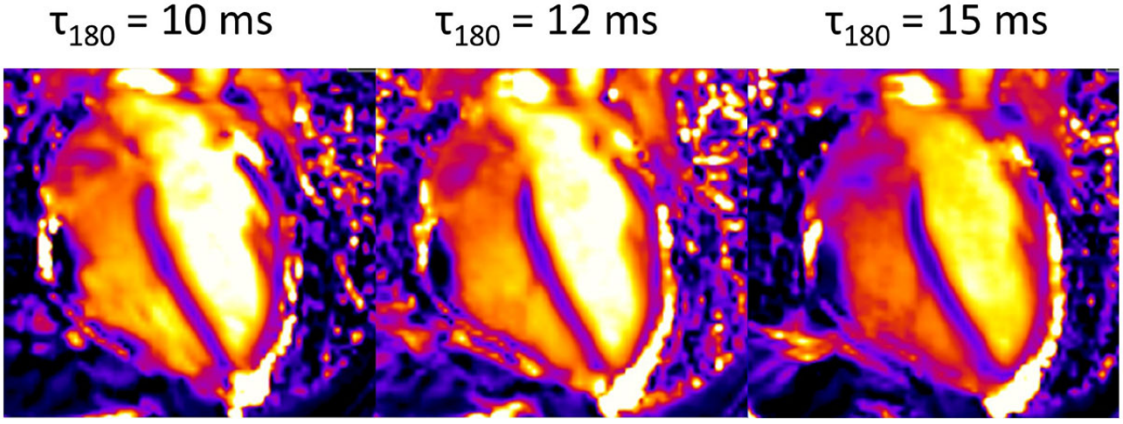

Figure 1 T2 prepared SSFP quantitative T2 maps (four-chamber view) acquired in a volunteer at different τ_{180} (10, 12 and 15 ms).

[1]Department of Biomedical Engineering, The Ohio State University, Columbus, OH, USA
Full list of author information is available at the end of the article

Table 1

τ180 (ms)	TET2p (ms)	Venous T2 (ms)	Arterial T2 (ms)	Estimated Parameters
10	0,20,40,80,120	125.7 ± 11.7	169.4 ± 12.8	SvO2: 72.6 ± 5.1% T2o: 168.6 ± 12.8 ms τex: 5.4 ± 3.5 ms
12	0,24,48,96,144	122.2 ± 9.8	176.4 ± 22.6	
15	0,30,60,120	110.6 ± 13.2	161.2 ± 16.7	

The T2 preparation times (TET2p) at which T2 maps were acquired for a specific τ180, the mean ± SD of venous and arterial T2 values measured in an ROI in the right and left ventricles in all volunteers, and mean ± SD of the parameters estimated from the maps.

estimated parameters. Venous and arterial blood T2 agree with previously reported values at 3T [2,3]. Estimated SvO_2 for all volunteers falls within the normal physiological range (60-80%).

Conclusions

The measured T2 of blood is dependent on Hct, O2 saturation, and τ_{180}. We have shown that if these parameters are known, SvO_2 can be non-invasively determined from arterial and venous blood T2 maps acquired at multiple τ_{180}. This provides in-vivo, patient-specific calibration, and may reduce the uncertainty and error in SvO2 estimation from applying a general calibration factor to the entire patient population. Although in this preliminary study we have assumed a fixed Hct and SaO_2 for all subjects, greater accuracy may be achieved by measuring individual Hct and SaO_2 from a blood sample and a pulse oximeter respectively. Nevertheless, our results show that the proposed approach is feasible, giving reasonable SvO_2 estimates. Future studies will involve validation of the single assumed parameter, α, in the T2-SO_2 model, optimization of the set of τ_{180} times, and further evaluation of the accuracy and precision of T2 mapping in determining blood O2 saturation. This would lead to the development of rapid, accurate, non-invasive, in-vivo quantification of SvO_2 from T2 maps, which would be highly beneficial for heart failure and congenital heart disease patients.

doi:10.1186/1532-429X-18-S1-W29
Cite this article as: Varghese et al.: Venous oxygen saturation estimation from multiple T2 maps with varying inter-echo spacing. *Journal of Cardiovascular Magnetic Resonance* 2016 **18**(Suppl 1):W29.

Authors' details
[1]Department of Biomedical Engineering, The Ohio State University, Columbus, OH, USA. [2]Dorothy M. Davis Heart and Lung Research Institute, The Ohio State University Wexner Medical Center, Columbus, OH, USA. [3]Department of Electrical and Computer Engineering, The Ohio State University, Columbus, OH, USA. [4]Siemens Healthcare, Columbus, OH, USA. [5]Division of Cardiovascular Medicine, Department of Internal Medicine, The Ohio State University Wexner Medical Center, Columbus, OH, USA. [6]Department of Radiology, The Ohio State University Wexner Medical Center, Columbus, OH, USA.

Published: 27 January 2016

References

1. Wright GA, *et al*: *JMRI* 1991, **1**:275-283.
2. Lu H, *et al*: *MRM* 2012, **67**:42-49.
3. Qin Q, *et al*: *MRM* 2011, **65(2)**:471-479.
4. Wright GA, *et al*: *MRM* 1991, **17**:126-140.